

## **Appendix B: RF Link Budgets**

**SATNET:** The following technical information is presented to assist personnel who operate SATNET satellite reception systems. The information presented is for reference purposes only; for assistance with actual satellite design requirements for your location, please contact HQ AFRTS or AFRTS-BC engineering.

**DTS:** The following technical information is presented to assist personnel who operate DTS satellite reception systems both aboard ship and at land based locations. The information presented is for reference purposes only; for assistance with actual satellite design requirements for your location, please contact AFRTS. For DTS shipboard applications please contact Naval Media Center, Washington, DC, or the Space and Naval Warfare Systems Command, San Diego, CA.

**RF Link Budgets:** An RF link budget is primarily a series of calculations that determine the signal loss between a satellite transmitter and a given earth station or receive antenna. The main consideration in these calculations is downlink carrier-to-noise density ( $C/N_0$ ) which is represented by equation (1):

$$C/N_0 = EIRP - PL + G/T + 228.6 \quad (1)$$

Where:

EIRP = Satellite's Effective Isotropic Radiated Power expressed in dBW. The satellite operator specifies this figure. For the SATNET and DTS C-Band Service, in the POR, AOR, the EIRP is 29 dBW, and the SATNET Ku-Band Service's EIRP is 47.7 dBW.

PL = Path Loss expressed in dB. This is the free space dissipation of the satellite's transmitted power as a function of distance. The PL calculation is shown in equation (2) below.

G/T = Earth station figure of merit expressed in dB/K. The G/T calculation is shown in equation (3) below.

228.6 = Boltzmann's constant expressed in dB/K/Hz.

$$PL = 185.0 + 10\text{LOG}[1-(0.295 \text{ Cos}H \text{ Cos}AL)] + 20\text{LOG}(\text{Frequency in GHz}) \quad (2)$$

Where:

H = Earth station latitude

AL = Difference in longitude of the satellite and the earth station

$$G/T = \text{Net Antenna Gain} - 10\text{LOG}(\text{System Noise Temperature}) \quad (3)$$

Where:

Net Antenna Gain = antenna gain – waveguide losses – coupler mismatch losses

System Noise Temperature = LNB noise temperature + antenna noise temperature + VSWR noise contribution and mismatch loss + interface waveguide noise.

### Typical SATNET C-Band Link Budget

Conditions	
Beam type	Global Beam
Antenna Size (Rx)	4.5 M
Antenna Size (Tx)	18 M
Symbol Rate	28.0 Msym/sec
Usable Information Rate	42.58 Mbps
Reed-Solomon Inner Coding	188/204
Coding Rate	$\frac{3}{4}$

Parameter	Uplink Values	Downlink Values	Units
<b>I. Uplink</b>			
Earth Station EIRP	80.4		dBW
Pointing Loss	0.5		dB
Path Loss	200.2		dB
Rain Attenuation	0.1		dB
Isotropic Antenna Area	37.0		dB/m <sup>2</sup>
SFD at Beam Edge	-83.0		dBW/ m <sup>2</sup>
G/T at Beam Edge	-10.0		dB/K
Uplink Thermal C/N	23.3		dB
Uplink IM EIRP Density	10.0		dBW/4kHz
Uplink Intermodulation C/N	31.5		dB
Total Uplink C/(N+I)	22.7		dB

<b>II. Transponder IM Noise</b>			
IMP Density at Beam Edge	-36.0		dBW/4kHz
C/IM	23.3		dB

<b>III. Downlink</b>			
Beam Edge XPDR EIRP		29	dBW
Path Loss		196.3	dB
Earth Station G/T		24.2	dB/K
Downlink Thermal C/N		7.3	dB

<b>IV. Co-Channel Interference</b>		30.0	dB
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<b>V. Total C/(N+I) Noise</b>			
Total C/(N+I)		9.3	dB
C/(N <sub>0</sub> + I <sub>0</sub> ) Total		81.78	dB-Hz
Information Rate in dB		76.29	dB
E <sub>b</sub> /N <sub>0</sub> Total		7.86	dB
E <sub>b</sub> /N <sub>0</sub> Required		5.5	dB
Link Margin		2.4	dB

### Typical SATNET Ku-Band Link Budget

Conditions	
Beam type	Spot
Antenna Size (Rx)	1.8 M
Antenna Size (Tx)	9.0 M
Symbol Rate	17.18 Msym/sec
Usable Information Rate	20.00 Mbps
Reed-Solomon Inner Coding	188/204
Coding Rate	$\frac{3}{4}$

Parameter	Uplink Values	Downlink Values	Units
<b>I. Uplink</b>			
Earth Station EIRP	73.2		dBW
Pointing Loss	0.5		dB
Path Loss	207.1		dB
Rain Attenuation	0.1		dB
Isotropic Antenna Area	44.4		dB/m <sup>2</sup>
SFD at Beam Edge	-90.0		dBW/ m <sup>2</sup>
G/T at Beam Edge	0.0		dB/K
Uplink Thermal C/N	19.3		dB
Uplink IM EIRP Density	10.0		dBW/4kHz
Uplink Intermodulation C/N	24.3		dB
Total Uplink C/(N+I)	18.1		dB
<b>II. Transponder IM Noise</b>			
IMP Density at Beam Edge	-36.0		dBW/4kHz
C/IM	40.5		dB
<b>III. Downlink</b>			
Beam Edge XPDR EIRP		43.3	dBW
Path Loss		205.1	dB
Earth Station G/T		23.1	dB/K
Downlink Thermal C/N		14.9	dB
<b>IV. Co-Channel Interference</b>			
		30.0	dB
<b>V. Total C/(N+I) Noise</b>			
Total C/(N+I)		12.9	dB
C/(N <sub>0</sub> + I <sub>0</sub> ) Total		87.77	dB-Hz
Information Rate in dB		24.0	dB
E <sub>b</sub> /N <sub>0</sub> Total		11.48	dB
E <sub>b</sub> /N <sub>0</sub> Required		5.5	dB
Link Margin		6.0	dB

### DTS Link Calculations

Conditions			
Beam type	Global Beam		
Antenna Size (Rx)	1.2 M		
Antenna Size (Tx)	11 M		
Symbol Rate	3.68 Msym/sec		
Usable Information Rate	4.52 Mbps		
Reed-Solomon Inner Coding	188/204		
Coding Rate	2/3		
Parameter	Uplink Values	Downlink Values	Units
<b>I. Uplink</b>			
Earth Station EIRP	81.5		dBW
Pointing Loss	0.5		dB
Path Loss	200.0		dB
Rain Attenuation	0.0		dB
Isotropic Antenna Area	37.0		dB/m <sup>2</sup>
SFD at Beam Edge	-82.0		dBW/ m <sup>2</sup>
G/T at Beam Edge	-12.0		dB/K
Uplink Thermal C/N	31.9		dB
Uplink IM EIRP Density	10.0		dBW/4kHz
Uplink Intermodulation C/N	41.9		dB
Total Uplink C/(N+I)	31.5		dB
<b>II. Transponder IM Noise</b>			
IMP Density at Beam Edge	-36.0		dBW/4kHz
C/IM	35.4		dB
<b>III. Downlink</b>			
Beam Edge XPDR EIRP		29.0	dBW
Path Loss		196.7	dB
Earth Station G/T		12.0	dB/K
Downlink Thermal C/N		7.3	dB
<b>IV. Co-Channel Interference</b>		30.0	dB
<b>V. Total C/(N+I) Noise</b>			
Total C/(N+I)		7.3	dB
C/(N <sub>0</sub> + I <sub>0</sub> ) Total		72.9	dB-Hz
Information Rate		66.55	dB
E <sub>b</sub> /N <sub>0</sub> Total		6.37	dB
E <sub>b</sub> /N <sub>0</sub> Required		5.0	dB
Link Margin		1.4	dB